ADAPTIVE ANTENNA TUNING SYSTEM FOR IMPROVING CELLULAR CALL RECEPTION IN MOBILE DEVICES

PRIORITY CLAIM

[0001] This application claims benefit of priority of U.S. Provisional Patent Application Ser. No. 62/646,246 titled "Adaptive Antenna Tuning System for Improving Cellular Call Reception in Mobile Devices", filed on Mar. 21, 2018, which is hereby incorporated by reference as though fully and completely set forth herein.

FIELD OF THE INVENTION

[0002] The present application relates to wireless communications, and more particularly to antenna tuning during wireless communications, for example during 3GPP LTE and/or 5G-NR communications.

DESCRIPTION OF THE RELATED ART

[0003] Wireless communication systems are rapidly growing in usage. In recent years, wireless devices such as smart phones and tablet computers have become increasingly sophisticated. In addition to supporting telephone calls, many mobile devices now provide access to the internet, email, text messaging, and navigation using the global positioning system (GPS), and are capable of operating sophisticated applications that utilize these functionalities.

[0004] Long Term Evolution (LTE) has become the technology of choice for the majority of wireless network operators worldwide, providing mobile broadband data and high-speed Internet access to their subscriber base. A proposed next telecommunications standard moving beyond the current International Mobile Telecommunications-Advanced (IMT-Advanced) Standards is called 5th generation mobile networks or 5th generation wireless systems, or 5G for short (otherwise known as 5G-NR for 5G New Radio, also simply referred to as NR). 5G-NR proposes a higher capacity for a higher density of mobile broadband users, also supporting device-to-device, ultra-reliable, and massive machine communications, as well as lower latency and lower battery consumption, than current LTE standards. Additionally, there exist numerous other different wireless communication technologies and standards. Some examples of wireless communication standards in addition to those mentioned above include GSM, UMTS (WCDMA, TDS-CDMA), LTE Advanced (LTE-A), HSPA, 3GPP2 CDMA2000 (for example, 1×RTT, 1×EV-DO, HRPD, eHRPD), IEEE 802.11 (WLAN or Wi-Fi), IEEE 802.16 (WiMAX), BLUETOOTH™, etc.

[0005] The ever increasing number of features and functionality introduced in wireless communication devices also creates a continuous need for improvement in both wireless communications and in wireless communication devices. In particular, it is important to ensure the accuracy of transmitted and received signals through user equipment (UE) devices, for example, through wireless devices such as cellular phones, base stations and relay stations used in wireless cellular communications. In addition, increasing the functionality of a UE device can place a significant strain on the battery life of the UE device. Thus it is very important to also reduce power requirements in UE device designs while allowing the UE device to maintain good transmit and receive abilities for improved communications.

[0006] The UEs, which may be mobile telephones or smart phones, portable gaming devices, laptops, wearable devices, PDAs, tablets, portable Internet devices, music players, data storage devices, or other handheld devices, etc. may have multiple radio interfaces that enable support of multiple radio access technologies (RATs) as defined by the various wireless communication standards (LTE, LTE-A, 5G-NR, Wi-Fi, BLUETOOTH™, etc.). The radio interfaces, which oftentimes use shared antennas, may be used by various applications and the presence of the multiple radio interfaces may necessitate the UE to implement solutions to seamlessly run applications simultaneously over multiple radio interfaces (for example, over LTE/LTE-A and BLUETOOTH™) without impacting the end-to-end performance of the application. That is, the UE may need to implement solutions to simultaneously operate multiple radio interfaces corresponding to multiple RATs (for example, LTE/LTE-A, 5G-NR, Wi-Fi, BLUETOOTH™, etc.).

[0007] One solution aimed at improving device functionality is antenna tuning. As wireless devices, such as those mentioned above for example, continue to evolve to support multiple wireless technologies that use shared antenna(s), the use of antenna tuning (for example the tuning of antenna (s) based on a variety of factors) has become an important tool for improving the overall performance of mobile devices. In one aspect, antenna tuning helps recover performance lost due to the ever shrinking volume or size of physical antennas. In many systems, antenna tuning involves the use of dynamic tuning techniques that improve antenna performance. Antenna tuning can include dynamic impedance tuning and/or aperture tuning. In impedance tuning, the impedance of the radio frequency (RF) front end circuit, for example the interface of the RF front end circuit communicatively coupled to the antenna(s), is tuned, to improve system efficiency. In aperture tuning, the antenna radiation is adjusted without actually having to modify the structure of the antenna, to improve antenna radiation efficiency. Antenna tuning therefore enables smaller antennas to operate more efficiently, facilitating the design of slimmer and thinner antennas.

[0008] Since the radio frequencies or frequency bands of operation of the different wireless technologies (or RATs) are often different while using shared antenna(s) within a device, the antenna efficiency depends on the frequency of operation and the antenna tuning. Therefore, where multiple wireless technologies are active (operating) at the same time, the tuning of antenna(s) for one active wireless technology can impact the performance of other active wireless technologies within the device. The extent and focus of the tuning can greatly vary depending on the operational needs and use of the device, and determining the most appropriate or most efficient antenna tuning in any given scenario remains a challenging task.

[0009] Other corresponding issues related to the prior art will become apparent to one skilled in the art after comparing such prior art with the disclosed embodiments as described herein.

SUMMARY OF THE INVENTION

[0010] Embodiments are presented herein of, inter alia, methods for adaptive, dynamic applications-based and/or service-based antenna tuning in devices for efficient and reliable wireless communications, for example LTE and/or 5G-NR cellular communications. Embodiments are further